Experimental Study of SLD Impingement Effects

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Abstract

Aircraft flying through clouds below 8000 meters (approximately 26,000 ft) at subsonic speeds can experience ice formation on critical aerodynamic surfaces. This situation can lead to deterioration of aircraft aerodynamic performance and handling qualities. Typically, ice accretion results from small super-cooled droplets (droplets cooled below freezing), usually 5 to 50 microns in diameter, which can freeze upon impact with the aircraft surface. Recently, however, ice accretions resulting from super-cooled large droplets (SLD) have become a safety concern. The impact of SLD ice accretions on aircraft safety, certification, and rulemaking is under evaluation by the Federal Aviation Administration (FAA). Furthermore, the design, certification, and evaluation of ice protection systems for SLD icing conditions require an improved understanding of the SLD impingement phenomena.

A major concern in the design and certification of ice protection systems for aircraft is the extent and amount of water impingement. The impingement characteristics of an aircraft can be used to determine size and location of ice protection systems. Computer codes are often used as a cost-effective means for the design of ice protection systems. It is important, however, that these codes are validated with experimental impingement data. Current ice accretion codes have been extensively tested for the FAR (federal aviation regulations) Part 25 Appendix C icing conditions. However, these codes have not been validated for SLD icing conditions and therefore they cannot be used as a means of compliance. To address this issue, the FAA Icing Plan has identified the validation of ice accretion codes as an important task (Task 11) for future research efforts.

The main objective of this two-year research program is to develop experimental methodologies for investigating and measuring SLD impingement, including investigation of droplet splashing and break-up. Droplet splashing and break-up were recently identified as having a significant impact on the impingement characteristics of aerodynamic surfaces, particularly for SLD conditions. Experimental SLD impingement data will also be obtained for a range of airfoil geometries to support the validation of ice accretion computer codes.

Experiments were conducted with a NACA 0012 airfoil section in a small icing wind tunnel facility to investigate large droplet impingement phenomena such as splashing and break-up. Advanced flow visualization techniques were used to document SLD splashing during impingement. The basic SLD physics experiments were followed by extensive impingement tests in the NASA icing research tunnel facility with a range of airfoils to develop the required SLD impingement database for code validation and calibration. The research findings will be compiled in a final report, which will be submitted to the FAA at the end of this research program.